Why is engineering design important for all leaners?

openaccessgovernment.org

22 March 2023

Engineering design systematically identifies needs, wants, and problems and then devises solutions to address them. A central component of our work is guiding students in the engineered design of solutions to local environmental problems

Science in society and schools must be for all citizens. Reasons include the desire to prepare citizens with the tools and knowledge to address local and global problems. With funding from the U.S. National Science Foundation, we foster sustained learning of Science, Technology, Engineering, and Mathematics (STEM) for students from primary school through university.

Engineering design systematically identifies needs

Engineering design systematically identifies needs, wants, and problems and then devises solutions to address them (NASEM, 2020). A central component of our work is guiding students in the engineered design of solutions to local environmental problems. Our program follows a seven-step process: Define, Research, Design, Build, Feedback, Place, and Educate.

Using STEM to Design Solutions

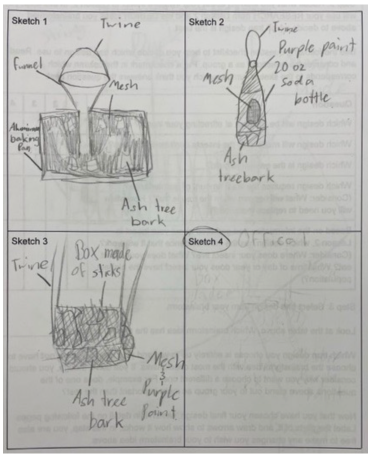
We designed a six-week curricular unit for youth ages 11-13 that extends environmental science learning through the seven stages of engineering design. In our program, students Define the problem as a local invasive insect disrupting a local ecosystem. An invasive species is an organism that is not native to the local environment and can harm the economy, environment, or human health. In teams, students conduct Research on one invasive insect, including food, habitat needs, and predators (if any). Next, they brainstorm at least three Designs for a trap that can collect their invasive insect. Student trap designs take into account the phase of the life cycle of the invasive insect, pheromones or lures to attract their insect, trap placement, and the construction of a cost-effective trap that can be maintained over time. Feedback includes sharing designs with other student teams and local environmentalists. Place includes locating the time of year and location for the most effective capture. Finally, Educate includes synthesizing key ideas from their designs to inform local stakeholders about possible implementation in their area.

	Students	Teacher
Providing Choice or Autonomy	"Wait, are we not making an open top?" "The string only needs to be a couple of inches long."	"This table overspent, so they have to dial back. Another table only spent $3 and is calling it good. It's interesting which tables are going the extravagant route and which are going simple."
Promoting Personal Relevance	"It [our insect] is in the part of [the state] we live in!" "We plan to place our trap near some box elder trees on the [local] trail."	I think they're more excited with this because it was something they could actually do, and they could kind of visualize doing it in our schoolyard…They're like, 'This is real. This is tangible,' so I felt like they were quite excited. [The program] tied in so many different things, like outdoor observations, research on a local invasive species, and trap building."
Presenting Appropriately Challenging Material	"I don't think a Boxelder Bug can fit through that hole [in the mesh on the trap top]." "Oh, let's cut a bigger hole in the middle."	"They were so excited once we actually built [the traps]. Some of them were like, 'But if I would have done this again, I would have used these materials.' So many of them put the fruit in on day one, but it had fermented overnight, so they were, 'I should have waited to put the fruit in." So it was cool that they were able to see kind of a process of fail and succeed."
Situating the Investigations Socially and Culturally	Students were very excited when 'Jeff,' a Brown Marmorated Stink Bug, crawled up the ramp in a test of design and attractants. "Our trap is working!" "Now we have evidence that our trap works!"	"I feel like they're more engaged in ecosystems because they understand it, they get it. They see life everywhere they see.""Like every resource [for building traps] that was there was something that most of them have in their houses."

Great STEM Learning Is Appropriately Challenging and Relevant

Why is it necessary to design pre-university programs that foster the engineered design of solutions?

Research indicates that programs must support students' engagement and motivation to be effective, as motivation drives the ability to use science, technology, engineering, and mathematics in critical decision-making processes (NASEM, 2018). A recent policy document from the National Academies of Science, Engineering, and Mathematics (NASEM, 2018, p. 67) suggests four design features that promote interest and motivation in STEM learning environments:



1. Providing choice or autonomy in learning
2. Promoting personal relevance

3. Presenting appropriately challenging material, and
4. Situating the investigations in socially and culturally appropriate contexts.

Our program emphasizes each of these four design features. The table illustrates what students and teachers said about elements of the curricular program associated with each design feature.

Engineering design programs exemplify our vision for K-16 STEM education

Engineering design programs such as this one exemplify our vision for K-16 STEM education because they provide learners with experiences that foster motivation, sustained engagement, and an appreciation for STEM. They also help learners find meaning and value when their STEM learning is used to solve local problems.

References

- National Academies of Sciences, Engineering, and Medicine. 2018. Sciencecand Engineering for Grades 6-12: Investigation and Design at the Center. Washington, DC: The National Academies Press. https://doi.org/10.17226/25216.
- National Academies of Sciences, Engineering, and Medicine. 2020. Building Capacity for Teaching Engineering in K–12 Education. Washington, DC: The National Academies Press. https://doi.org/10.17226/25612.